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for hydrochloric acid presented in this article are 0.795, 0.844, and 0.945. The value (0.738) for potassium chloride at 0.1 molal is again much smaller (namely about 14% smaller) than the conductance-ratio (0.861).

A more complete description of this research will soon appear in the *Journal of the American Chemical Society.* The preparation of the cells so as to secure constancy and reproducibility of the electromotive force values, the methods of making the measurements, the full experimental data, and thermodynamic calculations from them of other free-energy values will be there presented in detail.

This research has been carried on with the coöperation of Prof. A. A. Noyes and with the aid of a grant made to him by the Carnegie Institution of Washington. The preliminary experiments were made jointly with Dr. Louis Weisberg, and the final measurements with Mr. Frank W. Hall. For all this assistance I wish to express my great indebtedness.

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EFFECTS OF CENTRIFUGAL FORCE ON THE POLARITY OF THE EGG OF CREPIDULA

By Edwin G. Conklin

DEPARTMENT OF BIOLOGY, PRINCETON UNIVERSITY

Read before the Academy, November 16, 1915. Received, January 22, 1916

If the eggs of the marine gasteropod Crepidula plana are subjected to centrifugal force of approximately two thousand times gravity the yolk is thrown to the distal or centrifugal pole, the oil and other light substances to the centripetal pole, while the nucleus and centrosphere together with most of the cytoplasm occupy the middle zone between the other two. In eggs centrifuged after fertilization and before the first cleavage the yolk zone comprises a little more than three-quarters of the volume of the whole egg, the middle zone a little less than one-quarter and the oil zone about one sixty-fourth, the relative volumes of the three being 49:14:1. In normal eggs of this stage the nucelus centrosphere and most of the cytoplasm lie near the animal pole, but in centrifuged eggs these formative substances may be displaced far from this position, the yolk, for example, being thrown to the animal pole and the protoplasm to the vegetative pole, or these displacements may take place in any other axis. Nevertheless these substances slowly come back to their normal positions provided there is sufficient time for this before the next cell division. However if cell division intervenes before the egg substances have regained their normal positions there is usually an abnormal distribution of these substances to the two daughter cells and since these substances do not pass through partition walls this abnormal distribution persists throughout later development. In each of the daughter cells, however, the protoplasm goes to the animal pole and the yolk to the vegetative one and the subsequent development is as nearly normal in every respect as is possible, although it is not possible to entirely undo the effects of the earlier dislocation. These results are in substantial agreement with the earlier work of Morgan (1907, '09, '10), Lillie (1906, '09), Conklin (1910, '12), et al., on the development of centrifuged eggs of other animals.

We have in these cases one of the simplest examples of organic regulation in which the organization concerned is merely the polarity of a single cell. The fact that polarity and pattern of organization persist in an egg after cytoplasm, nucleus, centrosphere, yolk and practically all other visible constituents of the cell have been displaced far from their normal positions is most remarkable and mysterious. Is polarity the result of some immaterial influence, some 'entelechy,' which like a divinity 'shapes our ends, rough hew them how we will?' Is it a purely physiological phenomenon, dependent as Child (1911, '12, '13, '14) believes on the rate of metabolism at different poles? Or does polarity persist in some material substance which is not moved by centrifugal force? Investigators are not inclined to close the door to scientific research by a hasty resort to 'entelechy,' and differences in the rate of metabolism or of any other physiological process at two poles, when not due to differences in the environment, must be associated with differences in the material substances at those poles. Consequently it seems necessary to conclude that there is some material substance or relation of parts in these eggs which persists with relatively little change, in spite of the dislocations caused by centrifuging, and which is capable of bringing these substances back to their normal positions when centrifuging ceases, unless they have been isolated in the meantime by the interposition of partition walls.

What is this substance or relation of parts in which polarity persists? Lillie (1906) concludes that polarity is a property of the 'ground substance' of the egg, this substance being 'a fluid which has no filar, reticular or alveolar structure' but yet is 'firmly organized' so that it is not affected by centrifuging. The substances which are dislocated by centrifugal force are mere 'inclusions' in this 'ground substance;' consequently eggs in which these inclusions are forced to occupy abnormal positions are still capable of normal development since their 'ground substance' remains unaltered. It is evident from Lillie's use of this term that he means it to include what is commonly called 'protoplasm' as contrasted with the 'inclusions' or metaplasm.

In eggs which contain relatively little yolk it may appear possible to identify this 'ground substance' with the general protoplasm, but in the eggs of Crepidula, where the yolk constitutes more than three-quarters of the whole, the protoplasm, including under this term cytoplasm, nucleus and centrosphere, is moved bodily from one pole to another when the yolk is displaced from its normal position. If there is a 'ground substance' here which is not moved by centrifuging it must constitute a relatively small part of the general protoplasm of the egg.

There is good evidence that this is indeed the case and that while the greater part of the cytoplasm is more or less free to move under the influence of centrifugal force there is a portion which is denser and more resistent which is not stratified by centrifugal force. Indeed as long as an egg remains alive this stratification is never complete and the boundaries of the zones are neither plane surfaces nor are they sharply delimited as is the case in dead eggs which have been centrifuged. In Crepidula this denser and more resistant part of the protoplasm is found in the nucleus and centrosphere, in a thin peripheral layer which retains its position as long as the egg remains unbroken, and in a framework of strands which runs through the cell and connects the nucleus and centrosphere to the peripheral layer. During non-divisional stages these strands are slender and less resistant and may be stretched or distorted but are rarely broken. They hold the centrosphere and nucleus in a definite relation to each other and to the cell axis, the centrosphere always lying on the side of the nucleus toward the animal pole and next to the free border of the cell. In whatever axis the egg may be centrifuged and however far the centrosphere and nucleus may be carried from the animal pole, the centrosphere always retains this position on the animal pole side of the nucleus and often can be seen to be connected with the peripheral layer by strands of denser protoplasm.

During cell division the strands radiating from the centrosome are stronger and more resistant than during non-divisional stages so that it is much more difficult to move the mitotic figure than it is to shift the resting nucleus and centrosphere. Indeed it is practically impossible to move this figure when once the astral radiations are well developed without destroying the power of further development. On the other hand if nucleus and centrosphere are displaced from their normal positions during non-divisional stages and are prevented from returning by prolonged centrifuging they undergo division in these new positions and give rise to cells which are more or less removed from their normal places. Thus polar bodies and ectoderm cells may be caused to form at the vegetative pole or at any other point on the surface of the egg instead of at the animal pole; nevertheless the protoplasmic portions of the yolk-containing cells return to the animal pole when centrifuging ceases unless otherwise prevented. In some instances in which centrifuging took place in the two cell stage the normal positions of protoplasm and yolk are regained in one of the cells but not in the other. All such cases indicate that it is difficult but not absolutely impossible to change the polarity of eggs and cleavage cells, and that the persistence of polarity in centrifuged eggs and the restoration of dislocated parts to their normal positions is connected with a somewhat resistent framework of protoplasmic strands which preserve the relative positions of nucleus and centrosphere in the cell axis.

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THE EMISSION QUANTA OF CHARACTERISTIC X-RAYS

By David L. Webster

JEFFERSON PHYSICAL LABORATORY, HARVARD UNIVERSITY

Received by the Academy, January 15, 1916

At the meeting of the American Physical Society last April, Duane and Hunt announced that X-rays of any given length would be excited as a part of the general radiation from a tungsten target only if the potential applied to the tube was enough to give an electron a kinetic energy as large as the Planck quantum of that wave length. This law was confirmed and extended to a potential of 100 kv by Hull. Off hand one would expect it to apply to characteristic rays also; but, since some work of Whiddington suggests an exception here, it seemed desirable to test such rays with the spectrometer.

This was done with a rhodium target in a tube which Dr. Coolidge very kindly had made with one of his hot wire cathodes. The potentials were supplied by a storage battery of 20,160 cells, and could be measured to about 1%. Neighboring potentials could be compared to about 0.1%.